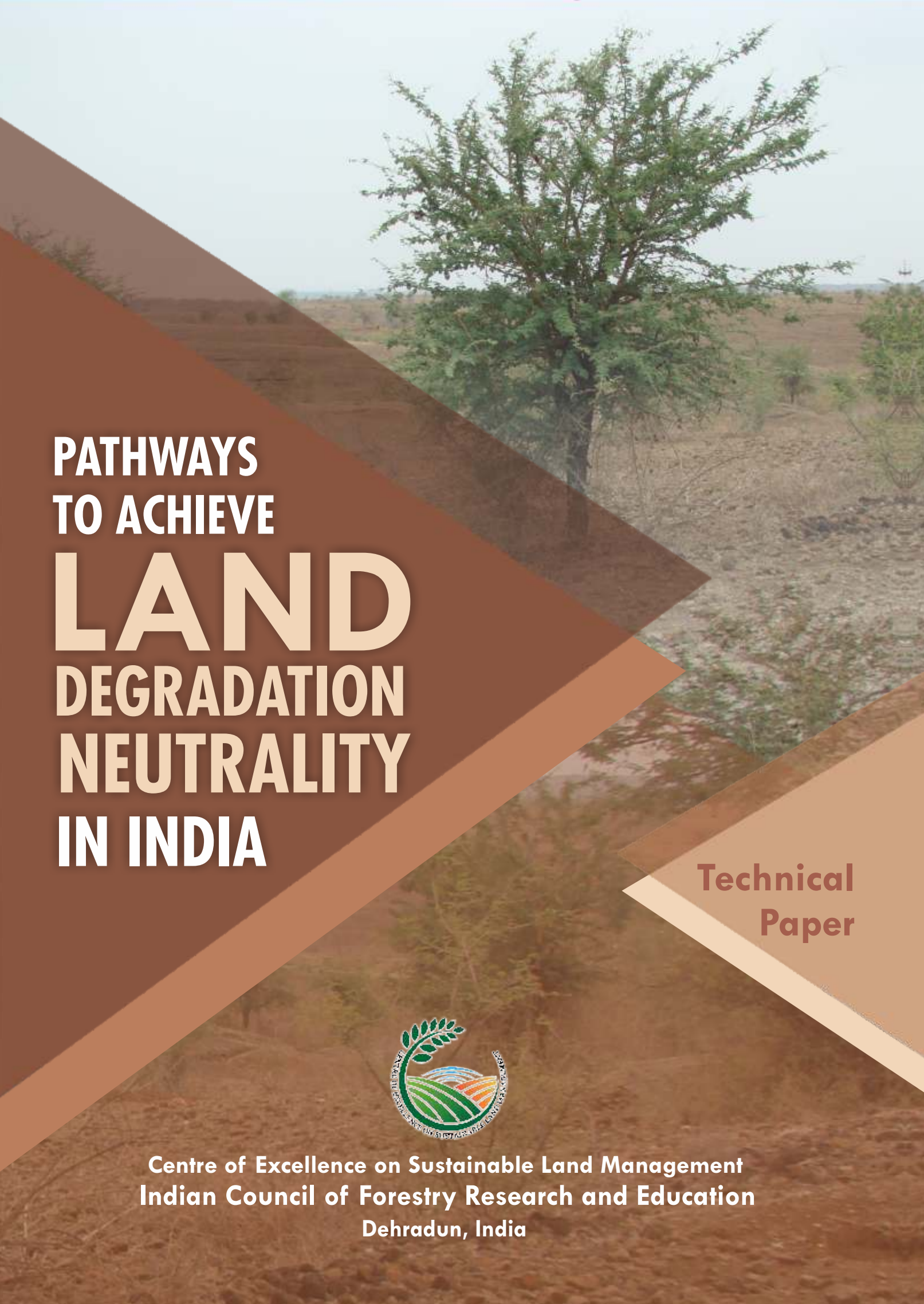

PATHWAYS TO ACHIEVE LAND DEGRADATION NEUTRALITY IN INDIA

Technical Paper

Centre of Excellence on Sustainable Land Management
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PATHWAYS TO ACHIEVE LAND DEGRADATION NEUTRALITY IN INDIA

CENTRE OF EXCELLENCE ON SUSTAINABLE LAND MANAGEMENT
INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
DEHRADUN, INDIA

Contents

Abbreviations

CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CADWM	Command Area Development and Water Management
CBD	Convention on Biological Diversity
CoE-SLM	Centre of Excellence on Sustainable Land Management
CoP	Conference of the Parties
CRIDA	Central Research Institute for Dryland Agriculture
DAY-NRLM	Deendayal Antyodaya Yojana and National Rural Livelihoods Mission
DDP	Desert Development Plan
DPAD	Drought Prone Areas Programme
EbS	Ecosystem Based Solutions
EIACP	Environmental Information Awareness Capacity Building and Livelihood Programme
ESA	European Space Agency
FAO	Food and Agriculture Organisation
FLR	Forest Landscape Restoration
FSI	Forest Survey of India
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Green House Gas Emissions
GIM	National Mission for a Green India
GIS	Geographical Information System
GLO	Global Land Outlook
GoI	Government of India
GSDP	Green Skill Development Programme
GSOC	Global Soil Organic Carbon
GLADIS	Global Land Degradation Information System
ha	Hectare
ICFRE	Indian Council of Forestry Research and Education
ILM	Integrated Land Management
ILUP	Integrated Land Use Planning
INBAR	International Bamboo and Rattan Organization
IPCC	Intergovernmental Panel on Climate Change
IRS	Indian Remote Sensing Satellite
ISFR	India State of Forest Report
ISRO	Indian Space Research Organisation
IUCN	International Union for Conservation of Nature

IWMP	Integrated Watershed Management Programme
JFMC	Joint Forest Management Committee
JRC	Joint Research Committee
LDN	Land Degradation Neutrality
LiFE	Lifestyle for Environment
LISS	Linear Imaging Self Scanning
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
mha	Million Hectare
MoEF&CC	Ministry of Environment, Forest and Climate Change
NAP	National Action Plan
NAP-CD	National Action Programme to Combat Desertification
NBM	National Bamboo Mission
NbS	Nature-Based Solutions
NDC	Nationally Determined Contributions
NDVI	Normalized Difference Vegetation Index
NFP	National Forest Policy
NPP	Net Primary Productivity
NRLM	National Rural Livelihoods Mission
NRSC	National Remote Sensing Centre
NWDPRA	National Watershed Development Project for Rainfed Areas
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
RAPD	Rainfed Area Development Programme
RLI	Red List Index
SAC	Space Applications Centre
SDGs	Sustainable Development Goals
SLEM	Sustainable Land and Ecosystem Management
SLM	Sustainable Land Management
SMC	Soil Moisture Conservation
SOC	Soil Organic Carbon
SPI	Science Policy Interface
Sq.Km	Square Kilometre
TGA	Total Geographical Area
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

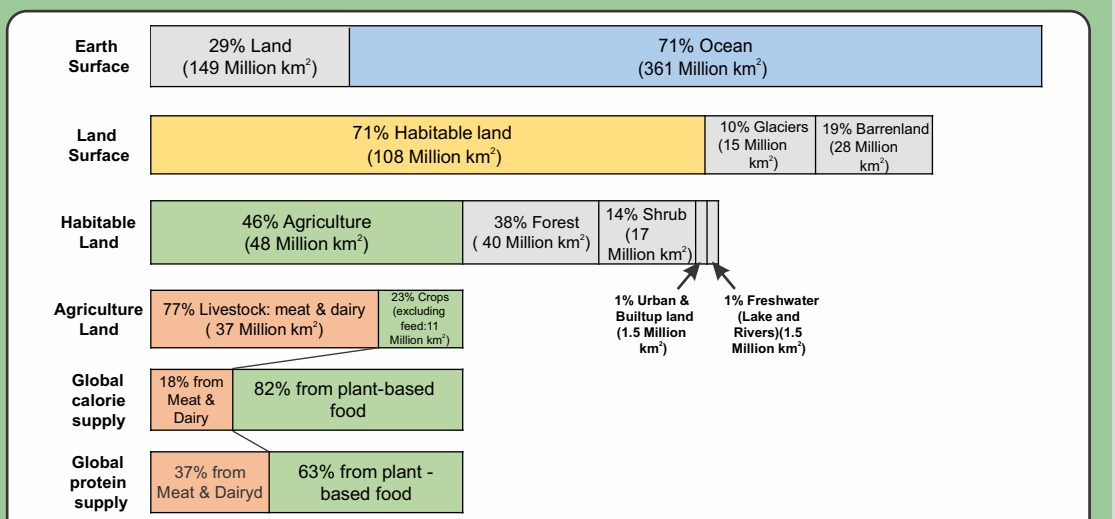
Land makes up approximately 29% (149 million km^2) of the planet's surface. Only 71% of the land is habitable, the other 29% is deemed inhabitable (UNCCD, 2019). The land is home to over 7.8 billion people, and many other life forms. About 0.28 million species of plant, 5.6 million species of animals, 0.61 million species of fungi, and 0.03 million species of Chromists, Archaea and Bacteria are estimated to inhabit different terrestrial ecosystems (Mora et al., 2011).

The terrestrial ecosystems provide array of goods and services necessary to support the biological diversity and human populations. However, the total land area is limited and so are the natural resources. Meeting the demands of the increasing population exerts additional pressure on the land and land resources. The unmindful exploitation of natural resources for meeting the demands of the population leads to depletion of natural resources and land degradation. Climate change has further aggravated the situation.

Land degradation is defined as "a state of continuous decline in the level of ecosystem services over an extended period" (Millennium Ecosystem Assessment, 2005). The United Nations Convention to Combat Desertification (UNCCD) defines desertification as "The land degradation in dry lands (i.e Arid, Semi-Arid, and Sub-humid region), which represents loss or a reduction of biological or economic productivity" (UNCCD, 2022). Land degradation reduces the productivity of natural resources and threatens biodiversity (Shao et al. 2016).

Land degradation has become a global concern as around 3 billion people are affected by land degradation (van der Wiel et al., 2017, IPCC, 2019). Climate variability and human activities are the major cause for land degradation in all primary drought-affected climatic zones in arid, semi-arid, and dry sub-humid nations (UNCCD, 2022).

BOX1: GLOBAL LAND USE



As per Ellis et al. (2010), 10% of the earth is glaciers, while 19% is barren land—deserts, dry salt flats, beaches, sand dunes, and exposed rocks. Thus, 71% of the total 108 million km^2 is habitable, 46% of habitable land is cultivated land amounting to 48 million km^2. Livestock occupies 77% of worldwide farming area, including pastures and feed crops (Poore and Nemechek, 2018). This leaves 38% for forests, 14% for shrubs and grasslands, 1% for freshwater, and 1% for built-up urban area, including cities, towns, villages, highways, and other human infrastructure

Source: Ritchie and Roser (2013)

1.1 Land-degradation at the Global-level

IPCC (2019) has highlighted a rise in population and per capita consumption, since 1961. Increased commercial agricultural and forestry production has supported population growth and food availability (Singh et al., 2022). This has led to changes in land use patterns, increase in GHG emissions, loss of natural ecosystems (forests, savannahs, natural grasslands, and wetlands), and loss of biodiversity. Anthropogenic activities and extensive use of the land have led to the degradation of 25% of the land areas (ice-free land). Various reports project different values for degraded land. As per GEF, 25% of the global land area is under degradation, as per the "World Atlas of Desertification" 75% of the global land area is under degradation (Cherlet et al., 2018). However, as per the Global Land Outlook, 2022, 40% of the global land area is under degradation (UNCCD, 2022).

Sub-Saharan Africa has 5% of human-degraded land, followed by Southern America with 17%. Both continents contributed 11% to global deterioration. South Asia has suffered the most, with human activity degrading 41% of its land, 70% of which is severe. Western Asia follows Southeast Asia with 20% of degraded land 75% of which is under severe degradation (FAO, 2021). Global estimates of human-induced land degradation in different regions are given in the Table 1.

TABLE 1: Global anthropogenic induced degradation classes in dry lands and humid areas (Food and Agriculture Organisation report for state of land, soil and water 2021).

Continent/Region	Area affected by Anthropogenic induced degradation (m ha)	Total Land area of region (m ha)	Percentage of affected region (%)	Strongly Degraded (m ha)	Slightly Degraded (m ha)
Sub-Saharan Africa	330	2413	14	149	181
Southern America	281	1778	16	153	128
South Asia	180	439	41	126	54
Northern America	177	2083	8	82	95
East Asia	156	1185	13	84	72
Western Asia	123	615	20	92	31
Southeast Asia	122	501	24	74	48
Australia and New Zealand	94	796	12	34	59
Eastern Europe and Russian Federation	83	1763	5	21	62
Western and Central Europe	56	489	11	12	44
Central Asia	31	456	7	12	19
Northern Africa	22	579	4	9	13
Central America and Caribbean	11	76	14	5	5
Pacific Islands	0.14	7	2	0.11	0.03
World	**1660**	**13178**	**13**	**850**	**810**

BOX 2: WORLD ATLAS OF DESERTIFICATION

The Joint Research Committee (JRC) released a new world atlas of desertification in June 2018. The salient findings of the World Atlas of Desertification are as under

- Over 75% of the Earth's land area is already degraded, and over 90% could become degraded by 2050.
- Globally, a total area half of the size of the European Union (4.18 million km^2) is degraded annually, with Africa and Asia being the most affected.
- Land degradation and climate change are estimated to lead to a reduction of global crop yields by about 10% by 2050. Most of this will occur in India, China, and sub-Saharan Africa, where land degradation could halve crop production.
- Because of accelerated deforestation, it will become more difficult to mitigate the effects of climate change
- By 2050, up to 700 million people are estimated be displaced due to issues linked to scarce land resources. The figure could reach up to 10 billion by the end of this century.

Source: Cherlet et al. 2018

1.2 Status of land degradation in India

In India, addressing land degradation and promoting restoration at a national scale assumes importance because of its impact on the economy and the well-being of millions. India is home to over 1.3 billion people, which amounts to 18% of the global population on 2.4% of the global land area (SAC, 2021). India also hosts 18% of the global livestock population. Of the total 328.72 mha, about 228.3 mha of land is classified as Arid, Semi-arid and Dry sub-humid areas, out of which 83.69 mha is under desertification.

Agriculture plays a vital role in India's economy, 54.6% of the total workforce of the country is engaged in agriculture and allied sector activities. As per the Ministry of Agriculture and Farmers Welfare (2021), the net sown area in the country is 139.42 mha of which 68.65 mha (49.24 %) is the net irrigated and the remaining approx. 70.77 mha. (50.76%) is rainfed. The rainfed area is typically characterized by resource-deficiency, land degradation and suffers vagaries of nature resulting in poor productivity.

The most recent mapping (2018-2019) of degraded lands in India by the Space Applications Centre (ISRO) reveals that, an area of 97.85 mha (29.77% of the Total Geographic Area (TGA) is under degradation (Fig 1). From 2003-05 to 2018-19 there is an increase of about 3.32 mha of land under degradation (Fig 1). The major drivers identified for this increase are water erosion, (affecting 11.01% of TGA); vegetation degradation, (affecting 9.15% of TGA); wind erosion, (affecting 5.46% of TGA) (Table 2).

Also, over the years geographical area affected by water erosion, vegetation degradation, water logging, frost shattering, mass movement, manmade, settlement has increased, at the same time geographical area affected by wind erosion and salinity has decreased, while the area under rocky barren land remained constant (Table 2).

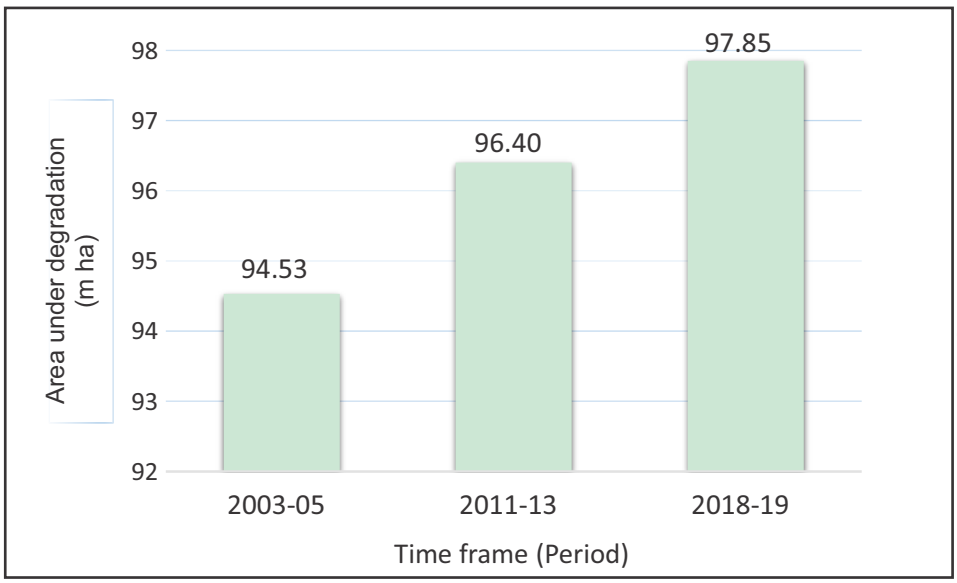


Figure 1: Area under degradation 2003-05 to 2018-19.

(Source: SAC, 2021)

TABLE 2: Drivers of degradation and the percent total geographical area affected by these drivers (SAC, 2021)

Drivers	2003-05	2011-13	2018-19
Water erosion	10.83%	10.98%	11.01%
Vegetation degradation	8.60%	8.91%	9.15%
Water logging	0.18%	0.20%	0.25%
Frost shattering	0.95%	1.02%	1.05%
Mass movement	0.26%	0.28%	0.29%
Manmade	0.11%	0.12%	0.19%
Settlement	0.47%	0.57%	0.69%
Wind erosion	5.58%	5.55%	5.46%
Salinity	1.22%	1.12%	1.11%
Barren/Rocky	0.57%	0.57%	0.57%

TABLE 3: State wise total area under degradation (million hectare) 2003-05, 2013-15 and 2018-19 (SAC, 2021)

States	Total area under degradation (million hectare)			Area under degradation (%)		
	2003-05	2011-13	2018-19	2003-05	2011-13	2018-19
Andhra Pradesh	2,267.73	2,298.76	2,378.04	14.16	14.35	14.84
Arunachal Pradesh	136.69	153.93	200.68	1.63	1.84	2.40
Assam	572.22	716.60	834.53	7.30	9.14	10.64
Bihar	659.54	694.81	746.59	7.00	7.38	7.93
Chhattisgarh	2,176.39	2,211.15	2,306.53	16.10	16.36	17.06
Delhi	73.51	89.87	91.54	49.57	60.60	61.73
Goa	186.46	192.97	194.88	50.37	52.13	52.64
Gujarat	10,077.46	10,261.64	10,248.06	51.35	52.29	52.22

Haryana	314.58	338.96	364.15	7.12	7.67	8.24
Himachal Pradesh	2,141.37	2,394.24	2,400.30	38.46	43.01	43.11
Jammu& Kashmir	966.80	1,064.72	1,129.50	17.86	19.67	20.86
Jharkhand	5,418.66	5,498.73	5,482.26	67.97	68.98	68.77
Karnataka	6,940.94	6,951.00	6,959.85	36.19	36.24	36.29
Kerala	370.51	379.59	422.30	9.54	9.77	10.87
Ladakh	6,578.65	6,911.57	7,111.97	39.14	41.12	42.31
Madhya Pradesh	3,771.85	3,804.32	3,859.74	12.24	12.34	12.52
Maharashtra	13,348.60	13,825.94	14,306.03	43.38	44.93	46.49
Manipur	593.09	601.96	612.57	26.56	26.96	27.44
Meghalaya	478.83	494.88	557.58	21.35	22.06	24.86
Mizoram	95.87	187.45	275.83	4.55	8.89	13.08
Nagaland	642.30	786.68	828.94	38.74	47.45	50.00
Odisha	5,321.90	5,304.11	5,359.01	34.18	34.06	34.42
Punjab	93.12	144.65	167.99	1.85	2.870	3.34
Rajasthan	21,625.60	21,526.51	21,237.67	63.19	62.90	62.06
Sikkim	78.48	78.75	84.61	11.06	11.10	11.92
Tamil Nadu	1,516.66	1,543.90	1,599.98	11.66	11.87	12.30
Telangana	3,658.48	3,598.86	3,638.51	31.86	31.34	31.68
Tripura	327.30	437.13	447.38	31.21	41.69	42.66
Uttar Pradesh	1,835.26	1,529.00	1,549.61	7.62	6.35	6.43
Uttarakhand	581.24	648.25	673.89	10.87	12.12	12.60
West Bengal	1,682.18	1,733.93	1,784.35	18.95	19.54	20.10
TOTAL	**94,532.28**	**96,404.85**	**97,854.85**	**28.76**	**29.32**	**29.77**

The land degradation atlas of India revealed that nine states viz. Rajasthan, Maharashtra, Gujarat, Ladakh, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana, account for 80% of total degraded lands. Since 2003-05, the land degradation has increased by more than 10% in fourteen states viz, Mizoram (188%), Punjab (80%), Arunachal Pradesh (47%), Assam (46%), Tripura (37%), Nagaland (29%), Delhi (25%), Jammu and Kashmir (17%), Meghalaya (16%), Uttarakhand (16%), Haryana (16%), Kerala (14%), Bihar (13%) and Himachal Pradesh (12%) (Table 3). The un-irrigated agricultural land and forest areas account for the 60% of total degraded land in India (Table 4) (SAC, 2021)

TABLE 4: Percent degraded land as per land use type (SAC, 2021)

Type of land use	Percent area degraded
Agriculture unirrigated	38%
Agriculture irrigated	8%
Barren	4%
Dune/Sandy area	6%
Forest	22%
Scrubland	14%
Periglacial	4%
Others	4%

2 Land Degradation Neutrality

Land degradation is one of the global environmental problem (Qadir et al. 2014) that also contributes to climate change and exacerbates loss of Soil Organic Carbon (SOC) and Nitrogen (Das et al., 2022). The idea of Land Degradation Neutrality (LDN) was first introduced as "zero net land degradation" in a proposal tabled at Rio+20 in 2012 at UN Conference on Sustainable Development. LDN is a condition where further land degradation (loss of productivity caused by environmental or human factors) is prevented and already degraded land are restored. LDN has been defined by the Parties to the Convention as "A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems" (Mukherjee et al., 2018). Management of land degradation has co-benefits for climate change mitigation, adaptation and biodiversity conservation, in addition to enhancing food security and sustainable livelihoods. Moreover, achieving LDN requires three concurrent actions:

1. Avoiding new land degradation through maintaining existing healthy land
2. Reducing existing land degradation by adopting sustainable land management practices
3. Taking efforts to restore and return degraded lands to a natural or more productive state.

2.1 Land based indicators for determining Land Degradation and Land Degradation Neutrality

As per decision 22 of COP11, six different progress indicators were adopted by the Conference of Parties to define LDN. Out of six indicators, three land-based indicators (namely land cover and land cover change, land productivity status and carbon stock value and changes) were defined to showcase or estimate the progress made towards achieving LDN. These three indicators are already monitored by the country party to the United Nations Convention to Combat Desertification (UNCCD) for reporting, and are in line with the Sustainable Development Goal (SDG) 15 and its indicator 15.3.1 (Proportion of land that is degraded over total land area). All three land-based indicators follow, One Out, All Out approach: which is based on if one of the sub-indicators is negative (during the baseline or reporting year) in a specific land unit, then that unit will come under degraded land, subject to ground validation by national authorities (UNCCD, 2018).

2.1.1 Land Cover

According to UNCCD, land cover data (spatial resolution 300 meters) of European Spatial Agency (ESA) can be considered for national reporting or land use/land cover data produced at the national level can also be used. The land use/ land cover data of seven different classes, namely forest, grassland, cropland, wetland, artificial area, bare land, and water body are used for reporting.

2.1.2 Land Productivity

To measure the land productivity, earth observations data on Net Primary Productivity (NPP) can be utilised. As per Pardos, (2005), NPP (kg/ha/year) is the net amount of carbon assimilated after photosynthesis and autotrophic respiration over a given period of time. The use of Remote Sensing/GIS techniques is one of the most effective ways to measure NPP at

national scales, at very fine resolution. Normalized difference vegetation index (NDVI), an indicator of green leaf productivity and biomass, is one common substitute to determine the primary productivity (Tucker, 1979).

2.1.3 Soil Organic Carbon

The third and most important land-based indicator Soil Organic Carbon (SOC) is difficult to estimate due to the spatial variability, lack of consistent time-series data and standardized SOC information system (Angelopoulou et al. 2019; Stumpf et al. 2018). Although, assessment and monitoring of SOC is expensive and time-consuming process, but it can also be generated using satellite earth observation data. This indicator can be derived from Global Soil Organic Carbon Map produced through Digital Soil Mapping under the Global Soil Partnership Framework (GSOC map developed by FAO, 2018).

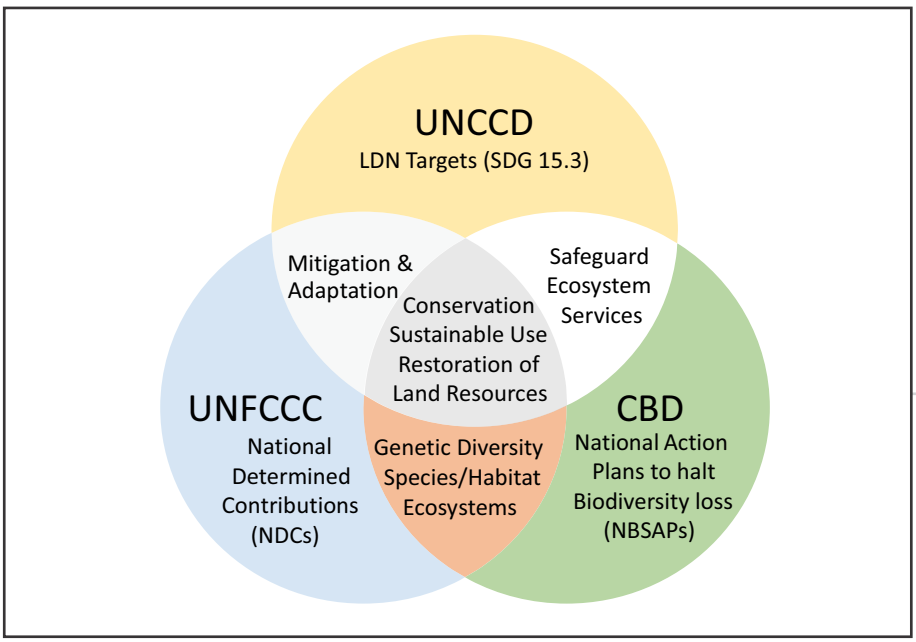


Figure 2: Linkages between UNCCD, CBD and UNFCCC and land as an operative link

(Source: UNCCD, 2022)

2.2 LDN in centre of three UN conventions

Land is the operative link between biodiversity loss and climate change. Achieving Land Degradation Neutrality through Sustainable Land and Ecosystem Management is key to protecting healthy and productive land, recuperating biodiversity, and carbon-rich ecosystems. Each convention establishes goals and targets, with country Parties developing action plans to implement at the national level. Bringing together national action plans that are currently separate under the UNCCD, CBD, and UNFCCC frameworks is an immediate way to align goals and commitments to restore land, get multiple benefits, and returns from the investments.

At the sixth session of COP 14, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services provided an aspiration towards addressing land degradation and the possible actions. Accordingly, Land Degradation Neutrality aspires to:

- **Safeguard biodiversity** through enlarged and more effective protected area system, halting conversion of natural land, large-scale restoration of degraded land, biodiversity offsetting where land transformation is unavoidable
- **Lower per-capita consumption patterns**, through adoption of low and renewable energy based industrial systems, transportation, housing and less land degrading diets (more vegetable based)

- **Improving gender equality** and moving towards improved access to education, voluntary family-planning, and social-welfare for ageing populations
- **Circular economy** promoting reuse and recycling of materials, reduced food loss and waste, sustainable waste and sanitation management system
- **Low input production systems** promoting efficient use of land-, energy-, water-, and material and low-emission production systems for food, fibre, bioenergy, mining, and other commodities
- **Sustainable land management** practices in croplands, rangelands, forestry, water systems, human settlements, and their surrounding landscapes, specifically directed at avoiding, reducing and reversing land degradation

BOX 3: LAND DEGRADATION NEUTRALITY UNDER VARIOUS INTERNATIONAL COMMITMENTS

International Commitments	Link with Land Degradation Neutrality
UNCCD	LDN has led convention implementation and SDG advancement, since 2015
UNFCCC	Forest Landscape Restoration (FLR) activities to deliver result-based payments for forest and land-use mitigation actions.
CBD	LDN and FLR contributions are linked to Aichi Targets 2, 5, 7, 11, 12, 13, 14, and 15
Bonn Challenge	The FLR methodology that underpins the Bonn Challenge can serve as a base for achieving national targets and agreements in a cooperative way.
SDG	LDN (SDG goal 15.3) is linked to SDG goals 1, 2, 5, 6, 7, 8, 12, 13

2.3 Landscape restoration contribution to Sustainable Development Goals

The LDN is part of one of the SDGs (SDG 15 life on land; 15.3 targets to end desertification and restore degraded land). However, it has synergies and trade-offs with other SDGs. Landscape restoration helps mitigate climate change (SDG-13.), provides food and forest products thus contributing towards SDG, 1, 2, and 12, improves air quality contributing to SDG 3, 11, improves biodiversity thus contributing to SDG-15, creates recreational opportunities (SDG 3,8,11), improves water quality (SDG 6, 14), provides sustainable timber fibre and fuel (SDG 2,5,10,12,16), creates rural jobs (SDG 1,5,10,16) and improves soil health (SDG, 12, 15). Full achievement of the Sustainable Development Goals contained in the "2030 Agenda for Sustainable Development" is likely to be possible through urgent, concerted, effective actions to reduce land degradation and promote restoration of the degraded lands.

2.4 India's commitment for achieving LDN

India has demonstrated leadership in addressing land degradation, initially pledging to restore 13 million hectares of degraded and deforested land by 2020 and an additional 8 million hectares by 2030 at the 21st meeting of the Conference of Parties (CoP) of the United Nations Framework Convention on Climate Change (UNFCCC). The earlier target to achieve 21 million hectares of land restoration by 2030 was also revised to 26 million hectares, as India chaired the COP 15 of the United Nations Convention to Combat Desertification in 2019 (UNCCD, 2019).

BOX 4: INDIA'S COMMITMENT FOR ACHIEVING LDN

India is one of the first countries to commit to the 2030 Sustainable Development Goal target of achieving land degradation neutrality (LDN)

India has raised its ambition for restoration of degraded land from 21 mha to 26 mha by 2030 under the Bonn Challenge

India has committed under the Paris Agreement to increase carbon sequestration through forests by 2.5-3 billion tonnes of carbon dioxide equivalent by 2030

India's national targets on restoration support implementation of national priorities on Sustainable Development Goals while contributing to the achievement of international commitments on climate change, biodiversity and land degradation

3 Integrated Land Use Planning (ILUP) vis-à-vis Integrated Land Management (ILM)

An Integrated Land Use Plan (ILUP) is a comprehensive planning tool that aims to promote sustainable land use practices and address land degradation. It involves the integration of multiple land uses, such as agriculture, forestry, and urban development, to ensure that land resources are used in a sustainable and equitable manner (Briassoulis, 2019; Karimi and Adams, 2019). An ILUP typically includes the following elements (Table 5).

TABLE 5 : Elements of Integrated Land use Plan

Resource Assessment	ILUP development begins with resource assessment. This involves mapping and assessing soil, water, vegetation, and wildlife. This assessment identifies land degradation and ecological and economic value.
Land Use Planning	Resource assessment-based land use planning: Land use zoning, which divides land by use, should be part of the plan. Forests and farms may be zoned differently. The land use plan should prioritise conservation agriculture, agroforestry, and soil and water conservation.
Stakeholder Engagement	ILUPs should include local communities and stakeholders from agriculture, forestry, and urban development. Stakeholder participation ensures the ILUP meets local priorities. It also boosts ILUP support and implementation.
Implementation Strategy	Develop an implementation strategy that details ILUP actions and resources. The strategy should prioritise sustainable land use and land degradation. It should identify funding and stakeholder partnerships.
Monitoring and Evaluation	Monitoring and evaluation of an ILUP should determine its efficacy and areas for improvement. ILUP indicators should assess land degradation, ecosystem services, and human well-being. New data and stakeholder input should inform the ILUP.

Overall, an ILUP is a useful tool for promoting sustainable land use practices and addressing land degradation. It involves a holistic and collaborative approach that can help ensure the long-term health and productivity of land resources.

ILUP to achieve Land Degradation Neutrality seeks to strike a balance between the economic, social, and cultural opportunities that land provides to different sectors and jurisdiction, and the need to maintain and improve ecosystem services provided by land based natural capital.

Integrated Land Management (ILM), on the other hand is a management approach that emphasises the sustainable use and management of a landscape's natural resources. This approach acknowledges that landscapes are complex systems that necessitate a holistic management strategy for sustainable development. By promoting more sustainable land

management practices, such as soil conservation, agro-forestry, and sustainable forestry, ILM can help reduce LDN. ILM is distinguished by characteristic participatory development processes (Table. 6)

TABLE 6: Key characteristics of Integrated Land Management approach

Shared Management Objectives	Shared or agreed upon management objectives providing multiple landscape benefits
Contribute to multiple objectives	Field practices designed to contribute to multiple objectives
Sustainability Synergy Management	Management of ecological, social, and economic interactions for the realization of synergies and the mitigation of trade-offs
Multiple stakeholders engagement	Collaborative, community engaged planning, management, and monitoring processes
Reconfiguration of market and policies	The re-configuration of markets and public policies to achieve diverse landscape objectives

Both ILUP and ILM have the potential to reduce LDN through the promotion of sustainable land use and management practices that conserve and restore ecosystems, enhance soil health, and support local livelihoods. However, their success is contingent upon effective implementation and coordination among various stakeholders, such as government agencies, civil society organisations, and local communities.

The 14th Conference of the Parties (COP) of the UNCCD requested that the Science Policy Interface provide science-based evidence on the potential contribution of ILUP and ILM to positive transformative change for achieving LDN and addressing desertification/land degradation and drought issues.

The Government of India has launched several schemes to address LDN in alignment with other SDGs. These schemes focus on protecting, restoring, and promoting sustainable use of terrestrial ecosystems. By addressing land degradation and promoting sustainable land use practices, these schemes can contribute to the achievement of LDN and the SDGs.

4 Existing Best practices for Integrated Land Management

Sustainable Land and Ecosystem Management (SLEM) is another prime approach to manage land and natural resources in a way that promotes sustainable development and protects the environment. Some of the SLEM management best practices of India are tabulated in Table 7.

TABLE 7: Best Sustainable Land and Ecosystem Management (SLEM) practices in India

Zero Budget Natural Farming (Bishnoi and Bhati, 2017)	The word 'budget' refers to credit and expenses, thus the phrase 'Zero Budget' means without using any credit, and without spending any money on purchased inputs. Zero Budget Natural Farming is a set of farming methods, and also a grassroots peasant movement, which has spread to various states in India. It has attained wide success in the southern Indian state of Karnataka where it first evolved. Debt is a problem for farmers of all sizes in India. Zero budget farming promises to drastically cut the production costs, thus ending the debt cycle of desperate farmers. 'Natural farming' means farming with Nature and without chemicals.
Banni Grassland Restoration, Kutch Gujarat (Dayal et al., 2018)	The programme aims to improve the ecosystem productivity and socioeconomic resilience of local communities dependent on grasslands.
Joint Forest Management in old Jalukie, Nagaland (Borah et al., 2018)	To cope with the issues of forest land degradation due to Jhum cultivation, the village council of Old Jalukie declared 370 ha of land as community biodiversity reserve and banned hunting, Jhum cultivation, logging, and green felling within the declared area.
Tata Power restoration efforts in Lonavala, Maharashtra (Borah et al., 2018)	The efforts of the Tata group of companies for restoration of degraded land increased green cover and faunal diversity in the Valvan Dam region of Lonavala.
Rainforest restoration in Valparai, Tamil Nadu (Mudappa et al., 2007)	Rainforest restoration efforts of Nature Conservation Foundation in Valparai has made magnificent changes in the region, by helping the restoration of fragmented rainforest patches through plantation of native tree species and mobilising native people for biodiversity conservation.
Improvement of community for drought proofing in Laporiya, Western Rajasthan (Everard and West, 2021)	This effort of Gram Vikas Nav-Yuvak Mandal, Laporiya, through the concept of conservation of Rainwater, improvement of pastures, and rainwater harvesting, and adopting animal based farming system were able to mitigate prevalent drought conditions. The innovative

	"Chauka' system for water conservation led to improvement of community pastures, and thus increasing the productivity of land.
Mangrove Afforestation in Sundarbans. (Vyas and Sengupta, 2012)	The project aims to develop strategies to combat climate change by capturing GHG through the restoration of mangroves. The activities of the projects empowered the villagers, especially women and resulted in gross community happiness, additionally the plantation of mangroves in the region resulted in increased biodiversity.
Paddy cum fish cultivation, West Bengal and Arunachal Pradesh (Yani and Sharma, 2018)	Paddy cum fish cultivation is a unique model that double the benefits earned by the paddy farmers, by land shaping technological interventions.
Tanka (water harvesting structure) of Barmer Rajasthan (Yadav, 2020)	Construction of Tanka, large water harvesting Structure under the Integrated Watershed Management Programme resolved the drinking water problem in the Deserts of Barmer District of Rajasthan.
Land restoration through Bamboo in Allahabad, Uttar Pradesh (Pathak et al., 2015)	UTTHAN, with INBAR used bamboo for restoration of degraded land and provided livelihood alternative to local farmers. About 10000 ha of degraded land in 600 villages in the states of Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar and Jharkhand has been reclaimed and over one million people got benefitted from this SLM practice.

These practices represent few of the many SLEM practices, which can be upscaled to promote sustainable development, protect the environment, and improve livelihoods for rural communities.

5 Land Degradation Neutrality in the context of India

Hon'ble Prime Minister of India Sh. Narendra Modi while addressing the high-level segment of the 14th Session of the Conference of Parties (CoP) to UNCCD in New Delhi in September 2019 stressed upon India's commitment for restoration of 26 mha of degraded land by 2030 and announced that a Centre of Excellence on Sustainable Land Management (CoE-SLM) at Indian Council of Forestry Research and Education (ICFRE), Dehradun will be established for promoting scientific approaches towards land degradation related issues. The Centre shall aim to assist developing countries under South-South cooperation in the capacity building towards development of land restoration strategies.

The Ministry of Environment, Forest and Climate Change (MoEFCC) as the national focal point for the implementation of the convention to combat desertification has been striving hard to achieve the goals of halting degradation and improving land. The CoE-SLM is making efforts to identify the degraded land and its major drivers and also developing site-specific appropriate sustainable land management practices to achieve LDN. The Centre has identified major institutions and collaborators that would be working towards the formulation and implementation of the strategies for addressing LDN.

The CoE-SLM is the focal point of MoEFCC for generating necessary reports and statistics for the national reporting to the UNCCD. Under this process, the Centre has mapped various indicators and generated statistics that would assist in formulation and implementation of strategies for achieving LDN. The information on (i) trends in land cover segregated as seven different classes of tree covered area, grassland, cropland, wetland, artificial surfaces, water bodies and bare land, (ii) trends in land productivity, (iii) trends in carbon stocks above and below ground, (iv) Proportion of land that is degraded over total land area (SDG goal indicator 15.3.1), (v) trends in population living below the relative poverty line, (vi) trends in access to safe drinking water in affected areas, (vii) trends in population exposure to land degradation disaggregated by sex, (viii) trends in the proportion of land under drought, (ix) trends in the proportion of the total population exposed to drought, (x) trends in the degree of drought vulnerability, (xi) trends in the overall extinction risk of species as mapped by IUCN using Red List Index (RLI), (xii) trends in protected area coverage, and, (xiii) information related to the mobilization of financial and other resources to support the LDN has been generated by the CoE-SLM for the baseline (2000-2015) and reporting periods (2016-2019). The available information and statistics would assist the policy makers and planners to achieve LDN and trace its progress.

The CoE-SLM has identified and mapped "hotspots" areas (Fig 3) at the national level where the vulnerability and severity of degradation is maximum compared to other areas and demands immediate attention. A well-planned action in these identified hotspot areas spread over 1,32,371.6 sq.km (approx. 4% of the total geographical area) provides an opportunity to restore the land to achieve the targets of LDN.

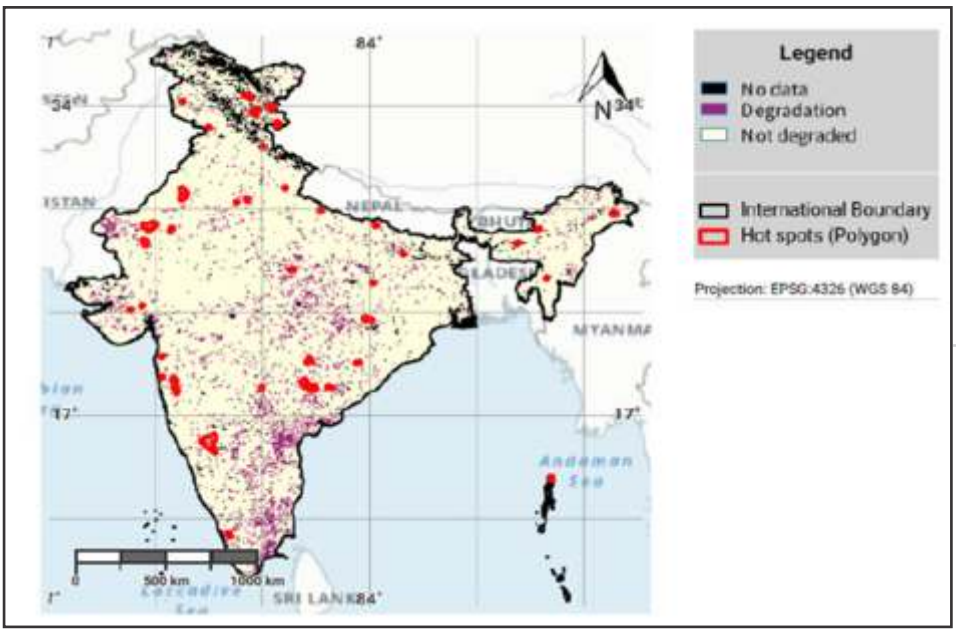


Figure 3: Hotspots area mapped for India in the reporting period 2016-2019.

The spatial spread of drought in India mapped for the year 2019 compared to all previous years indicate an improvement as the proportion of land cover under the drought decreased from 68% in 2000 to 37.5% in the year 2019. The proportion of land under drought was mapped as 53.9%, 61.4%, 59.0%, and 76.6% respectively for the year 2015, 2016, 2017, and 2018. The majority of drought class in the year 2019 falls under mild (27.13%) followed by moderate (5.76%), severe (2.51%) and extreme (1.40%) classes (PRAIS4, India National Reporting UNCCD Portal-2022). The spatial distribution of drought hazard class severity for the reporting period is shown in Fig 4.

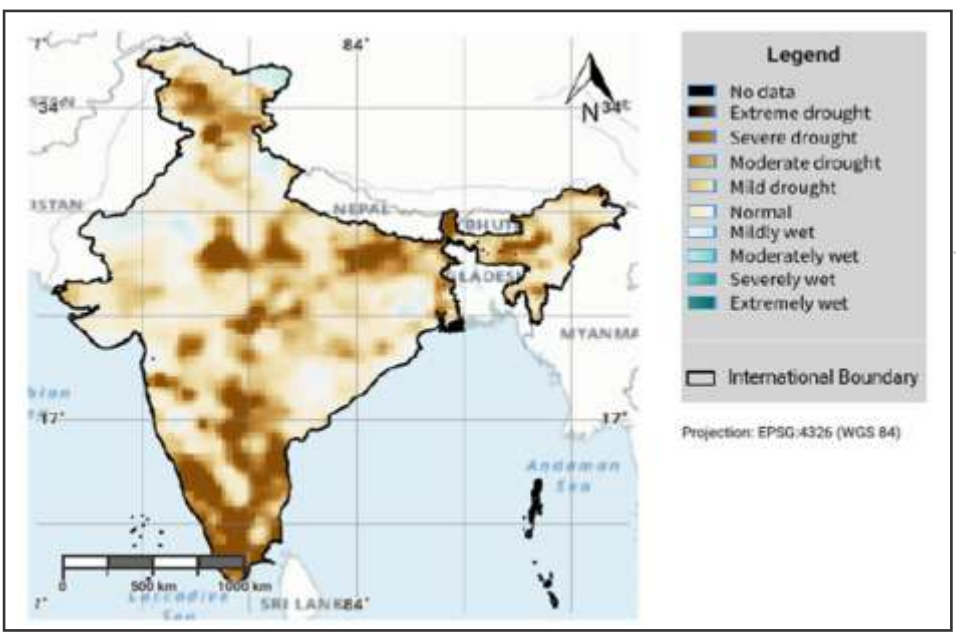


Figure 4: Drought severity classes mapped for India in the reporting period 2016-2019

The Government of India has made continuous efforts to improve land productivity and achieve LDN through projects like PMKSY, RADP, and MGNREGA. Mahatma Gandhi NREGA, the world's largest labor guarantee scheme, contributes to climate resilience, household income stability and promote women's participation. The 'Per Drop More Crop' scheme focuses on

water use efficiency through micro-irrigation. Watershed development addresses LDN in rainfed and degraded lands, with the construction of water harvesting structures. National Mission for Green India aims to increase forest and tree cover. The MoEFCC utilizes Environmental Information Awareness Capacity Building and Livelihood Programme (EIACP) Centers for skill development in the environment and forest sector. Regenerative agriculture, eco-tourism, and protected area management offer stable livelihood opportunities. Major initiatives under these schemes include climate-resilient land use practices, agroforestry, organic farming, afforestation, and reforestation. Initiatives like GIM, DAY-NRLM, and sustainable land use practices foster climate resilience and biodiversity conservation. India aims to involve all stakeholders in land restoration activities with convergence of the efforts of central and state governments to identify the challenges and opportunities and formulate site-specific strategies. Scaling up best practices and enhancing monitoring frameworks are essential to track LDN progress effectively.

5.1 LDN for achieving NDCs

Nationally determined contributions (NDCs) are climate action plans submitted by countries under the UNFCCC to reduce emissions. India updated its NDC in August 2022, pledging to reduce the emissions intensity of its GDP by 45% by 2030 compared to 2005 levels. The update also aims to achieve 50% of electric power capacity from non-fossil fuel sources and create a carbon sink of 2.5 to 3 billion tonnes through increased forest and tree cover. India's NDC emphasizes a mass movement called "LiFE" (Lifestyle for Environment) to promote sustainable living based on conservation values. This aligns with India's long-term goal of achieving net-zero emissions by 2070.

The implementation of the updated NDC (2021-2030) involves collaboration between relevant ministries, departments, states, and union territories. The government has launched various plans and programs to scale up adaptation and mitigation efforts, contributing to land improvement and addressing LDN. These efforts encompass water management, agriculture, forestry, energy, sustainable mobility, housing, waste management, circular economy, and resource efficiency, among other areas.

5.2 LDN for achieving sustainable development goals

The United Nations approved the Sustainable Development Goals (SDGs) in 2015 as a universal call to eradicate poverty, safeguard the environment, and ensure that by 2030, all people enjoy peace and prosperity (Fig 5). The 17 SDGs are interconnected, recognising that actions in one area will have an impact on outcomes in others, and that development must balance social, economic, and environmental sustainability. The SDGs aim to eliminate poverty, hunger, and gender discrimination against women and girls. LDN is closely linked to several SDGs, including SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 14 (life below water), and SDG 15 (life on land) (Fig 6).

Figure 5: Sustainable development goals (SDGs) as adopted by UNDP, (2015)

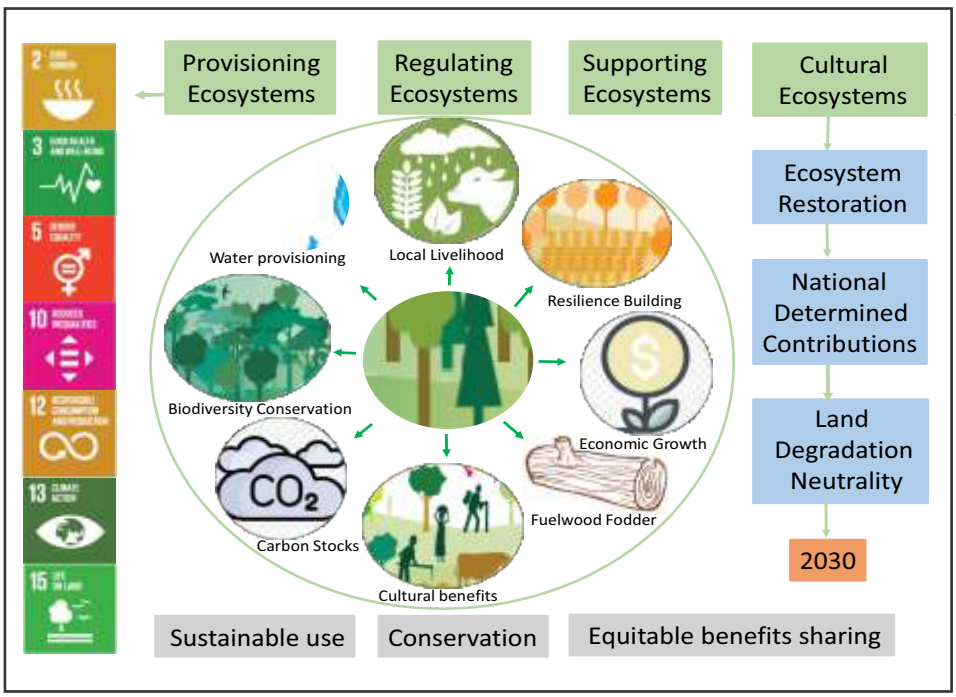


Figure 6: Linkages between Sustainable Development Goals (SDGs), Nationally Determined Contributions (NDCs) and Land Degradation Neutrality (LDN) (Kumar et al., 2022).

5.3 LDN for combating desertification

The measures taken to combat desertification is directly linked to LDN, enhancing ecosystem resilience and improve a range of ecosystem services. Combatting desertification by engaging rural and local communities provides the opportunity to improve livelihoods that eventually reduces the vulnerability of communities to drought and other climate related risks. Restored ecosystems would enhance a range of ecosystem services such as carbon sequestration, water retention and biodiversity conservation (Fig 6) which would further help to improve land productivity.

5.4 Carbon sequestration for achieving LDN

Conservation and management practices that are targeted towards carbon sequestration also aid in increasing the productivity and thus prevent land degradation and help to improve the

livelihoods of the communities. Management and conservation practices viz. Afforestation, Assisted Natural Regeneration, Conservation tillage and Climate Smart Agriculture, Blue carbon etc. help to lock carbon to atmosphere and fix it in in the form of biomass. These practices are also important for preventing land degradation and restoration of degraded land. Carbon sequestration in soil improves the productivity of land and is important for achieving LDN. Carbon sequestration, improving soil fertility and biodiversity are interlinked to each other. Recognising the importance of land for achieving Climate, LDN and Biodiversity targets IPCC calls for integrated response and synergies between the conventions for adaptation and mitigation to climate change.

6 Roadmap to achieve Land Degradation Neutrality (LDN)

Land degradation neutrality (LDN) is a global goal to keep or improve the quality and productivity of land resources while reducing the negative effects of land degradation on the environment, economy, and society. The LDN response hierarchy encourages broad adoption of measures to avoid and reduce land degradation, combined with localised action to reverse degradation, to achieve LDN across each land type. To reach the LDN, a comprehensive planning approach is needed that looks at the causes of land degradation and promotes sustainable ways to use land (Fig 7).

Figure 7: Roadmap to achieve land degradation neutrality

(Reference: UNCCD, (2018), UNCCD, (2019) and FAO, (2018))

BOX 5: THE LDN RESPONSE HIERARCHY

Avoid degradation through

- Conservation
- SLEM Best practices
- Sustainable Management of Pastures and Range Lands
- Soil Moisture Conservation (SMC) Interventions
- Conservation tillage

Reduce degradation by

- Restocking of degraded forest through gap-plantations
- Agroforestry models
- SLM best practices
  - WADI
  - CHAUKA
  - etc.....
- Assisted Natural Regeneration
- SMC Interventions
- Crop diversification
- Conservation tillage

Reverse degradation by

- Reclamation of problem soils
- SMC Interventions
- Mechanical, chemical and Biological interventions
- Bio-engineering methods

6.1 Afforestation

The conservation and restoration of forests, as well as increasing biodiversity and green cover, have always been accorded a high priority in policies, rules, and programmes. Also, the Centre and State governments have worked together to plant trees as part of various plans and schemes. From 2011-12 to 2021-22, a total of 18.94 m ha has been planted with trees (Table 6).

TABLE 6 : Afforestation achievements

Area covered (in million ha)	
Year	**Achievement**
2011-12	1.60
2012-13	1.63
2013-14	1.62
2014-15	1.35
2015-16	1.38
2016-17	1.99
2017-18	1.68
2018-19	1.63
2019-20	2.07
2020-21	2.21
2021-22	1.78
Total	**18.94**

(Source: NAP, 2023)

At the current rate, afforestation and eco-restoration activities are about 7 mha short of the target of 26 mha. For achieving the target of 26 mha, states with higher degradation and large open forest areas can be prioritized. As per Land Degradation Atlas prepared by SAC, (2021) nine states accounts for 80% of total degraded area and have large open forest area. As per SAC, 2021, unirrigated agriculture land and forest together accounts for 60% of total degraded land. Hence, these lands can be prioritized for LDN for achieving Bonn challenge.

6.2 DLD Atlas 2021 and ISFR 2021 desertification and open forest areas

According to Desertification and Land Degradation Atlas (2021) prepared by the Space Application Center, ISRO, Ahmedabad, 70% of India's drylands are undergoing desertification due to both climate and human-related factors. The high population density has led to excessive exploitation of dryland resources, including cultivation, grazing, deforestation, and water usage, which has resulted in the degradation of these areas.

TABLE 7: Status of degradation as per desertification and land degradation atlas 2021 (SAC, 2021) and and available open forest area ISFR 2021 (ISFR, 2021)

Name of the State	Total Area under Desertification (m ha)	% Total Area under Desertification w.r.t. GA	Open Forest Area (m ha)
Uttar Pradesh	1.550	6.43	0.816
Tamil Nadu	1.600	12.30	1.179
West Bengal	1.784	20.10	0.959
Chhattisgarh	2.307	17.06	1.637

Andhra Pradesh	2.378	14.84	1.386
Telangana	3.639	31.68	1.047
Madhya Pradesh	3.860	12.52	3.662
Odisha	5.359	34.42	2.395
Jharkhand	5.482	68.77	1.143
Karnataka	6.960	36.29	1.321
Gujarat	10.248	52.22	0.952
Maharashtra	14.306	46.49	2.148
Rajasthan	21.238	62.06	1.221
Ladakh	7.112	42.31	0.176
Uttarakhand	0.674	12.60	0.648
Himachal Pradesh	2.400	43.11	0.518
Total	**90.896**	**--**	**21.207**

TABLE 8: Status of degradation as per desertification and land degradation atlas 2021 (SAC, 2021) and and available open forest area ISFR 2021(ISFR, 2021) in the North-eastern States

Name of the State	Total Area under Desertification (m ha)	% Total Area under Desertification w.r.t. TGA	Open Forest Area (m ha)
Arunachal Pradesh	0.201	2.40	1.520
Assam	0.835	10.64	1.525
Manipur	0.613	27.44	0.947
Meghalaya	0.558	24.86	0.733
Mizoram	0.276	13.08	1.195
Nagaland	0.829	50.00	0.653
Sikkim	0.085	11.92	0.069
Tripura	0.447	42.66	0.186
Total	**3.842**	**--**	**6.827**

Around 9.34% of India's total forest area is categorized as degraded or open forests, (Table 7). Further, 76.87% of non-forest land offers an opportunity not only to restore degraded areas but also to increase the tree cover outside conventional forest areas through eco-restoration and landscape-specific measures. The Forest Survey of India (FSI) has identified ten activities to enhance carbon sinks and forest cover, with restoring degraded forests and afforestation on wastelands and agroforestry having the most significant potential to create additional carbon sinks. However, targeted interventions are required in states facing desertification or land degradation challenges, along with active community participation and the adoption of agroforestry practices to reduce landscape and community vulnerability.

Fifteen states of India which include Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Telangana, Uttar Pradesh, Uttarakhand, Tamil Nadu, Himachal Pradesh, West Bengal, and Maharashtra, can be prioritized for interventions to achieve the Land Degradation Neutrality targets based on ecological and geographical

conditions and extent of degradation (NAP, 2023). These states account for more than 25% of the country's geographical area, with a total area of 83.78 million hectares under desertification. In the Open Forest Area, only 30% are suitable for afforestation and can be treated to achieve LDN (NAP, 2023).

According to the Space Applications Center's Land Degradation Atlas (2021), there has been an increase in degradation in North-eastern states since 2003-05. Mizoram has seen the most significant rise in degradation, followed by Arunachal Pradesh, Assam, Tripura, Nagaland, Meghalaya, Sikkim, and Manipur (Table 8). These states have significant forest resources that need preventive and restoration measures to avoid further degradation.

The primary emphasis should be on implementing measures to mitigate desertification through the following activities-

1. Finding suitable sites for eco-restoration/afforestation using climate-resilient multipurpose tree species, perennial forage, and fodder species to decrease desertification
2. Preventing soil erosion via site-specific soil and water conservation methods
3. Developing and maintaining surface and subsurface drainage systems to reduce agricultural soil salinity and managing suitable irrigation systems
4. Proper land management for agriculture and farming

Further converging the above activities with the ongoing National and State Government Programmes like Joint Forest Management, Integrated Watershed Management Programme and Mahatma Gandhi National Rural Employment Guarantee Act, etc. will facilitate achieving targets of LDN.

BOX 6. EXAMPLES OF VARIOUS GOVT. SCHEMES FOR ACHIEVING LDN

Forestry sector Interventions

- Green India Mission
- Eco-development forces
- Nagar VanScheme
- Compensatory Afforestation
- Intensification of Forest Management Scheme
- Green Skill Development Programme
- National Coastal Mission

Agriculture sector interventions

- National Mission on Sustainable Agriculture
- National Bamboo Mission (NBM)
- Soil Health Cards

Watershed management interventions

- Integrated Watershed Management Programme (under PMKSY)
- Initiatives by State Governments under IWMP
- Namami Gange
- Atal Bhujal Yojana
- CADWM
- Rejuvenation of 13 major Indian rivers

Other initiatives

- National Livestock Mission Sub-Mission on Feed and Fodder Development
- Initiatives by State Governments under National Green Highways Mission

6.3 Landscape approach for achieving LDN

A landscape approach refers to a framework that combines policy and practice for multiple land uses through adaptive and integrated management systems. This process is collaborative, multi-faceted and intended to provide solutions at various scales, involving multiple stakeholders from different sectors. Its primary aim is to enable negotiation between stakeholders to account for trade-offs and maximize synergies, ultimately seeking to minimize losses and increase gains. It is a flexible framework that can function effectively at different levels and scales. This adaptability makes it particularly useful for addressing multiple challenges and evolving policies that may overlap or emerge over time. A successful implementation of the landscape approach includes built-in mechanisms for gradual adoption of new policies. The approach is also designed to remain locally relevant besides meeting national commitments. Overall, the landscape approach provides a resilient and responsive framework for navigating complex and dynamic policy environments. The ten principles of the landscape approach are depicted in Fig 8.

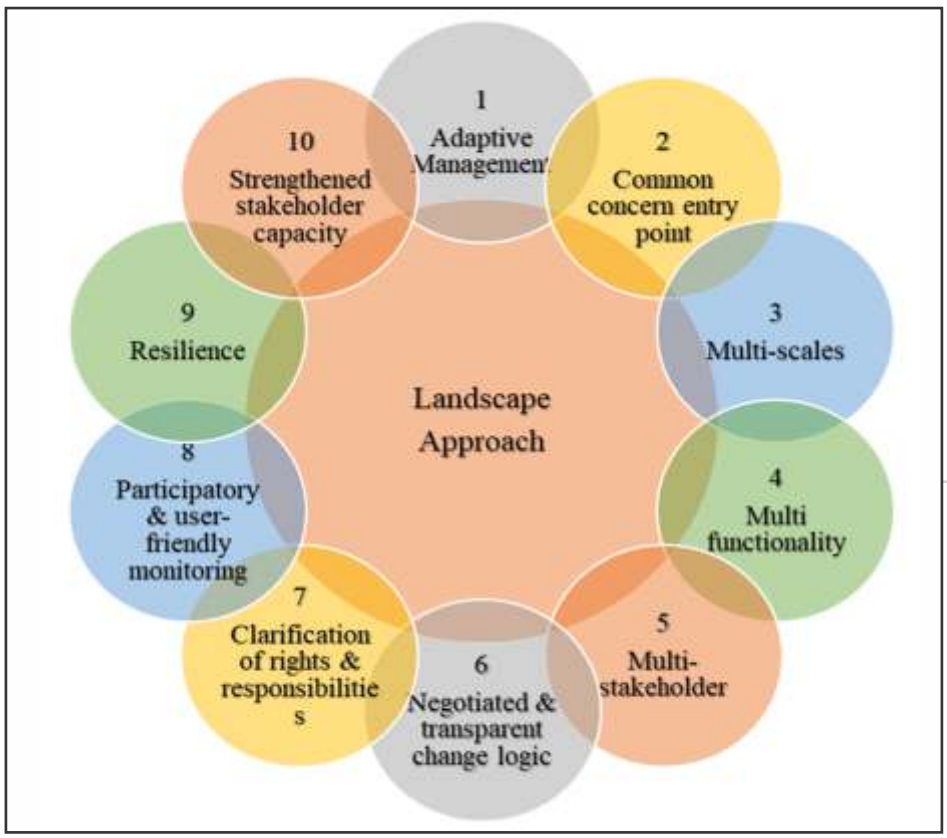


Figure 8: Landscape approach for achieving LDN and NDC targets with existing schemes

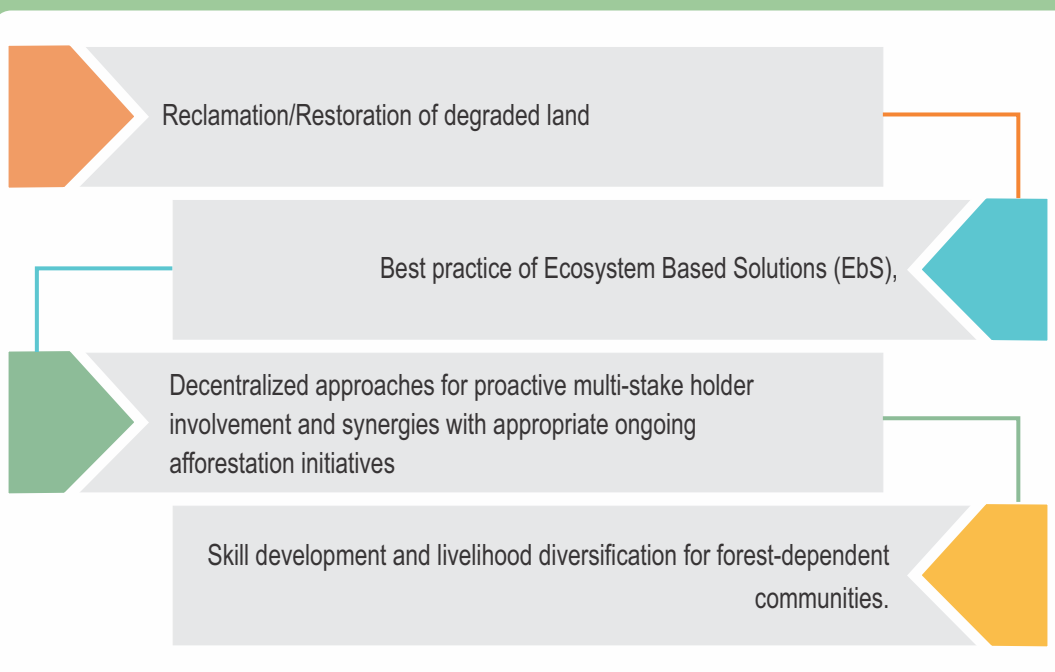
The landscape approach is a holistic way of thinking about land management that takes into account the interconnectedness of different components of an ecosystem, including human communities, natural resources, and biodiversity. It emphasizes the need to restore and reclaim degraded land through a combination of best practices in ecosystem-based solutions, decentralized approaches that involve multiple stakeholders, and synergies with ongoing afforestation initiatives. One of the primary goals of the landscape approach is to restore degraded land to a healthy and productive state. This can involve a range of activities, such as removing invasive species, restoring soil health, and creating habitat for wildlife. By restoring degraded land, the landscape approach helps to improve the resilience of ecosystems and the communities that depend on them (Reed et al., 2015).

Another key aspect of the landscape approach is the use of ecosystem-based solutions to address environmental challenges. This involves working with natural processes to solve problems,

rather than relying on artificial solutions. For example, to control erosion, the landscape approach involves planting vegetation that stabilizes the soil rather than building concrete structures (NAP, 2023).

Decentralized approaches are important part of the landscape approach, that assumes involvement of a range of stakeholders in land management decisions, including local communities, landowners, and government agencies that helps to ensure the needs and perspectives of different groups (NAP, 2023).

BOX 7. LANDSCAPE APPROACH EMPHASIZES



6.4 Multitier Landscape level planning and implementation

NDCs have become the bedrock of India's climate actions post-2020 and are also indicative of the country's "best-efforts" for sustainable development and poverty eradication. Several proactive eco-restoration interventions are being implemented to fulfill the inherent obligations as per the principles of common but differentiated responsibilities and respective capabilities and equity.

To implement India's Climate Action Plan post 2020, it is necessary to adopt a multitier landscape level planning and implementation approach. This involves designing and implementing restoration and regenerative interventions at various spatial scales, from global to local levels (Fig. 9). It aims to promote social and ecological benefits through collaborative efforts across different countries and regions. A holistic approach that considers the social, economic and ecological dimensions of restoration is essential. To achieve this, it is important to align restoration practices with national aspirations and state policies, empower representative of decision-making authority, and work closely with local communities to identify restoration priorities and implement locally appropriate restoration practices.

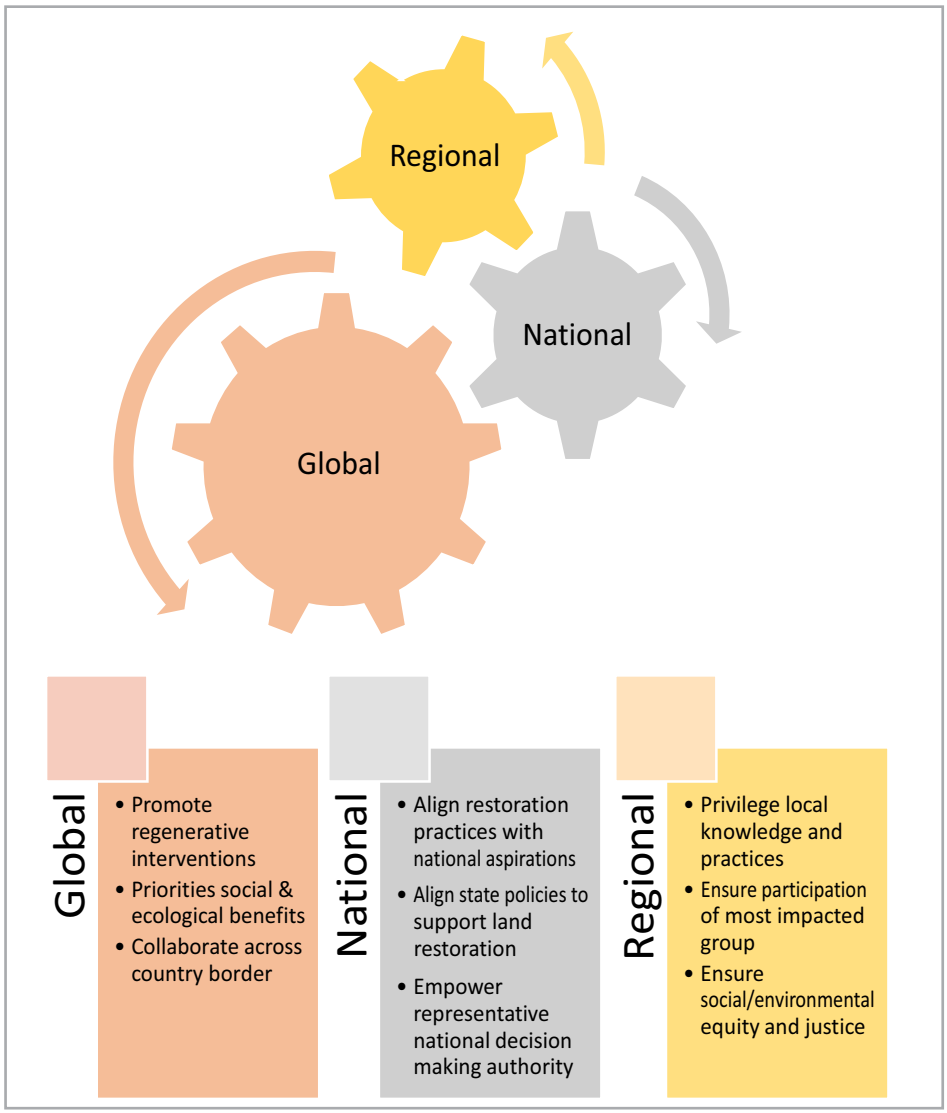


Figure 9: Multitier Landscape level planning and implementation

6.5 Convergence of Resources

The Ministry of Environment, Forest and Climate Change has released 'Convergence Guidelines for Integrated Greening Interventions' to provide a nation-wide coordinated effort for afforestation activities. The guidelines aim to address sustainable management of forest resources for climate change mitigation and promote better quality planning and selection of degraded sites for eco-restoration and afforestation interventions. The guidelines propose to implement holistic land treatment measures through convergence of various schemes and programs, helping achieve the country's target of restoring degraded areas by 2030.

The guidelines for Convergent Approach for Greening India has proposed a convergent and integrated approach for the comprehensive development and restoration plans for degraded landscapes. The approach includes efficient mapping of forest and non-forest areas to identify vulnerable and potentially vulnerable sites for afforestation and soil and water conservation activities. It also includes adopting an integrated national framework for collaborative annual plans to prioritize landscapes for rejuvenation of rivers and wetlands, biodiversity conservation, combating desertification, and enrichment of wildlife corridors (Fig 10). The guidelines propose a single portal approach for formulating state annual plans of operations and their implementation and reporting of state and district-wise achievements. The approach enables efficient planning, implementation, and monitoring of eco-restoration initiatives in the country, promoting sustainable management of forest and natural resources in vulnerable landscapes (NAP, 2023).

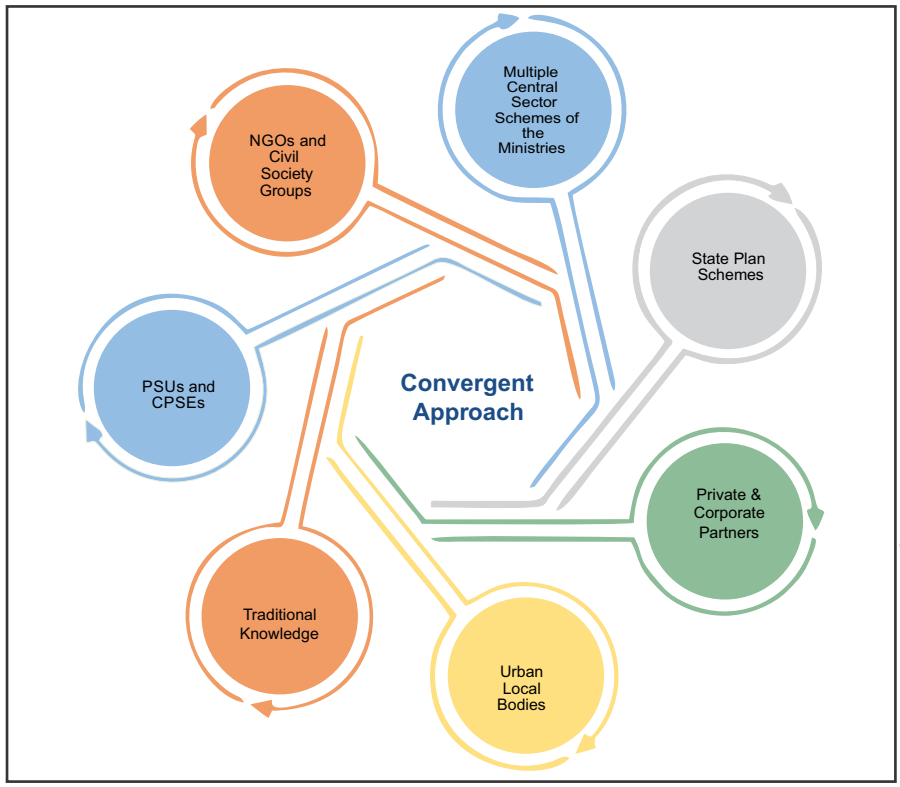


Figure 10: Problem-solving for LDN using a convergent strategy

6.6 Monitoring System for LDN

The Space Applications Centre (SAC), ISRO, Ahmedabad, along with 19 concerned partner institutes, monitors and prepares inventories of desertification across the nation. It utilises Indian Remote Sensing Satellites (IRS) data in a Geographical Information System (GIS). "Desertification and Land Degradation Atlas of India" depicts desertification and land degradation status maps of all States based on land use, processes, and severity. The findings of the reports help to pinpoint desertification and land degradation hotspots of the country. A four-tier monitoring system for LDN advancement is proposed to monitor the progress to achieve LDN in the country (Fig. 11.)

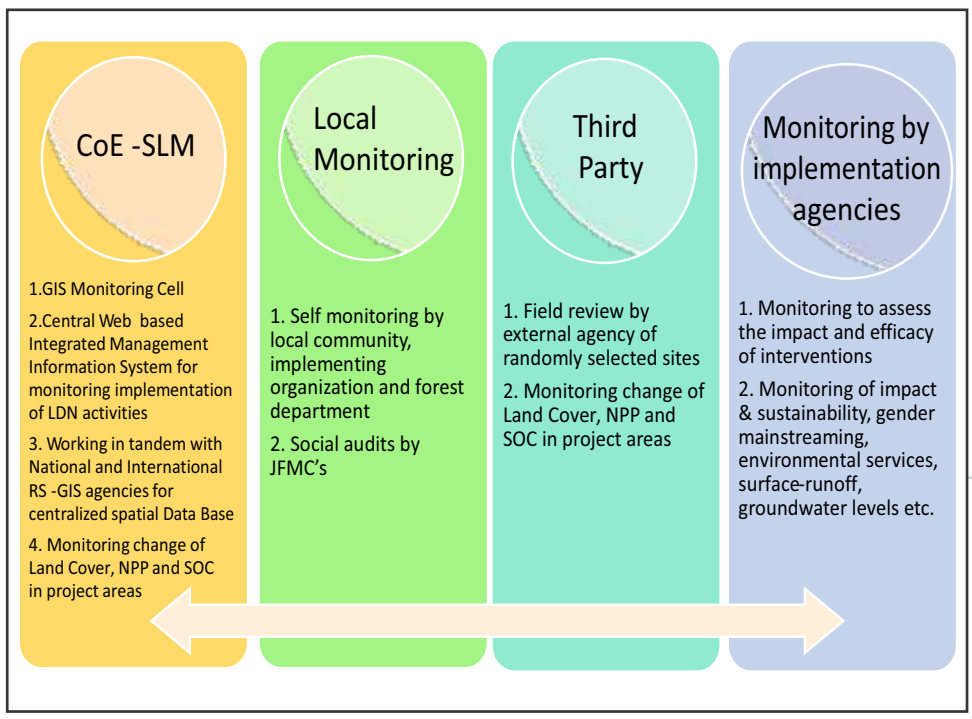


Figure 11: Proposed monitoring System for LDN

Gram-Sabha, JFMCs shall socially audit local operations, and the information will be made available in the public domain. Third-party and RS-GIS monitoring of UNCCD indicators for positive land cover changes, land productivity, and carbon stocks will be carried out on regular basis.

A web-based Integrated Management Information System Platform driven by GIS application in real time will be built at CoE-SLM to converge varied programmes for LDN that will include robust financial planning, timely funding, mobilisation and judicious use of financial resources. This web portal will be able to generate report of the progress regarding public/private sponsored projects being implemented across the country.

6.7 Capacity Building and Outreach

The ICFRE's Centre of Excellence on Sustainable Land Management (CoE-SLM) is the nodal agency for trainings, capacity building, outreach, and dissemination of national and international sustainable land management concerns. The CoE builds stakeholders capacities by proactive involvement of varied knowledge partners and top institutes using a multi-dimensional and multi-hierarchical strategy. The approach and elements of outreach strategy of CoE is depicted in the Fig.12 (NAP, 2023).

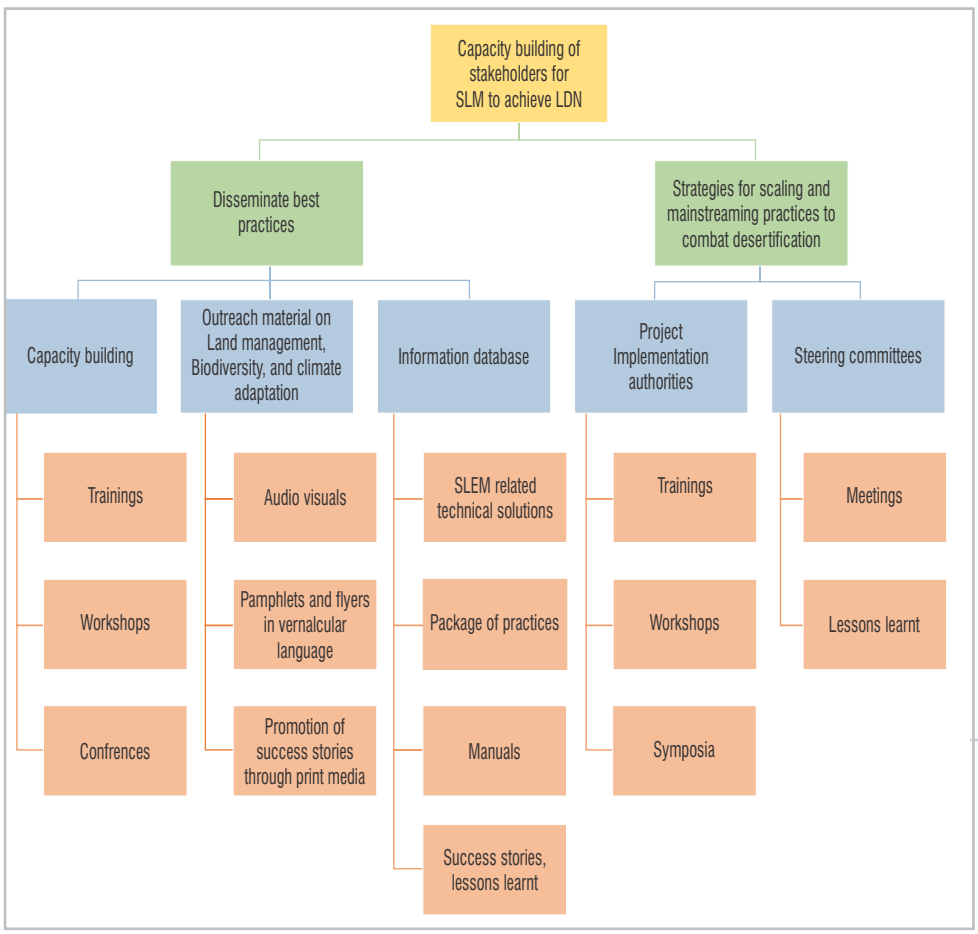


Figure 12: Components of capacity building

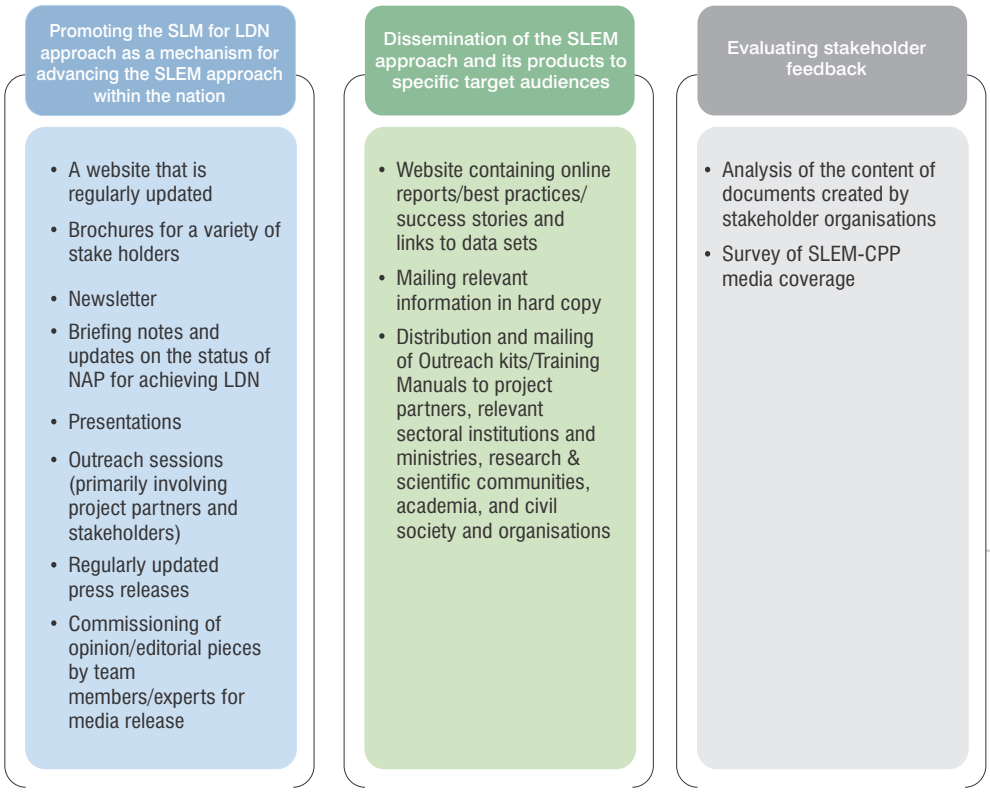


Figure 13: Elements of outreach strategy and proposed activities

Land management, biodiversity conservation, and climate change adaptation outreach material for decision-makers and practitioners will be generated using monitoring and framework data and site visits. Written, audio/visual, e-learning, field visits by subject specialists, semi-annual best practice notes in the vernacular language, mainstreaming models will comprise this outreach content. Conferences, Seminars, Training, Workshops, and other dissemination mechanisms will facilitate to share lessons learnt and ideas for scaling up and mainstreaming land degradation best practices (Fig. 13).

Workshops for project implementation authorities and personnel will explore these problems together with steering committee meetings. All Indian states, and LDN initiatives, will receive technical solutions. Leading SLEM-related NGOs will receive this information. A package of practices and manual will be created to scale and replicate successful land management, biodiversity protection, and climate change adaptation practices.

7 Conclusions

Soil and land degradation have extensively been influenced by both natural factors and human activities. It is imperative to take immediate action to halt degradation processes and restore degraded lands. Despite the availability of scientific knowledge and technology, much of it remains fragmented and lacks consensus. Therefore, conducting authoritative and frequent assessments of the type, degree, extent, and causative factors of soil and land degradation is of utmost importance.

Based on ecological and geographical conditions and extent of degradation, fifteen states of India including Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Telangana, Uttar Pradesh, Uttarakhand, Tamil Nadu, Himachal Pradesh, West Bengal, and Maharashtra, have been identified for interventions to achieve the LDN targets (NAP, 2023). These states account for more than 25% of the country's geographical area, with a total area of 83.78 mha under desertification. In the Open Forest Area, only 30% of open forest areas are suitable for afforestation and can be treated to achieve LDN.

Human activities on land can have positive impacts on certain aspects while simultaneously adversely affecting others. Therefore, more studies are required on the magnitude of impacts and the resulting trade-offs. The mitigating efforts are hampered due to divergent views on land degradation in relation to other challenges. A more systematic treatment of the views and experiences of land users would be useful in land degradation studies (IPCC, 2019).

There is a range of scientific methodologies available that could significantly enhance the accuracy, precision, and monitoring mechanisms for assessing land degradation and sustainable land management. However, their current utilization is limited by inadequate institutional protocols and formats. The Guidelines for Convergent Approach for Greening India propose an integrated and collaborative approach for the comprehensive development and restoration of degraded landscapes. This approach facilitates efficient planning, implementation, and monitoring of eco-restoration initiatives in the country, promoting the sustainable management of forests and natural resources in vulnerable landscapes.

The land degradation process can be restricted, however, it requires long term commitments. The investments for land improvement and better land management can definitely be encouraged through appropriate policies, improved information systems, increased development of research and technology, and above all, capacity development through effective training programmes which respond to the needs of all the stakeholders involved in land degradation management and thereby ensuring the maintenance of a relatively high land productivity.

In order to prioritize investments for efficient and effective LDN programme, coordinated international efforts are must. The increasing global investments in land resources offer the potential to assess the global economics of land degradation and implement recommended actions. It is important to align restoration practices with national aspirations and state policies, empower decision-making authority, and work closely with local communities to identify restoration priorities and implement locally appropriate restoration practices. Food security, environmental balance and land degradation are strongly inter-linked, that need to be addressed holistically while achieving targets of LDN.

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